

THE
NATURE
OF THE
NERVOUS FLUID,
OR
ANIMAL SPIRITS,
DEMONSTRATED:
WITH AN
INTRODUCTORY PREFACE.

*Corpus ipsum sibi ipsi idem est, & ex iisdem
conflatum.——Corporis pars minima omnia
habet, qualia quidem & maxima.*

Hippocrat. de Locis.

By MALCOLM FLEMING, M.D.

L O N D O N:

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TO

Dr. *P E T E R S H A W.*

S I R,

THE following pages may plead some right to your favour and friendly regard, as they are intended to explain, illustrate, and establish a Doctrine, set forth briefly and transiently, amidst other things equally abstruse and intricate, in a *Latin* epistolary dissertation I addressed to you, and published near twelve years ago : A Doctrine, which if it can be fairly maintained, may be of no small importance, as it tends to fill up a considerable chasm in our knowledge of the Animal Oeconomy.

That this Doctrine, such as it is, may become more generally known and attended to, and therefore of course more thoroughly tried and canvassed,

I have now sent it into the world single and uneclipsed by other subjects that might be more showy, cloathed in an *English* dress, and as clearly explained, and strongly supported, as I apprehended was at present necessary. To answer which ends the more effectually, I have inscribed it anew to you, whom I esteem and honour, not only as a rare patern, but likewise as a zealous encourager and promoter of medical knowledge, and indeed of almost every kind of useful and commendable learning.

That you may long prosper, and continue to labour successfully for the good of mankind, which you have so much at heart, is the ardent wish of,

S I R,

Your most devoted obedient Servant,

Novemb. 16.

1751.

Malcolm Flemyng.

P R E F A C E.

THAT the reader may clearly apprehend the scope and intent of the following short treatise, I have judged it proper to premise some things, and lay before him the occasion of my writing it, and my reasons for publishing it at this present time.

In the year, 1740, I published a Latin Poem on Hypochondriacal and Hysterical Diseases, entitled, Neuropathia, ushered in by a prose discourse in the form of an epistle, addressed to Dr. Shaw, explaining and enlarging upon some points relating to the principal subject, which could not be so fully and minutely discussed in a Didactic Poem, where a sententious conciseness must be kept up. In this discourse, after having laid down the existence of a nervous Fluid,

as a fundamental doctrine, and endeavoured briefly to take off Dr. Cheyne's objections against it, I proceeded next to enquire into the nature and constituent parts of that Fluid, in the passage which you will find in the original Latin at the end of this preface; a close translation whereof is as follows :

“ Before I dismiss this subject, I shall
 “ briefly enquire into the nature of the
 “ animal spirits. For all the authors I
 “ remember to have read, and my books
 “ are not just now at hand, give not sufficient satisfaction upon this head. On
 “ the contrary, I wonder that an easy
 “ and obvious manner of reasoning did
 “ not come into their minds, to this purpose ; as the animal spirits are the finest
 “ and most subtle of all the liquids in
 “ the animal body, the nerves must be
 “ nourished solely by these, it being impossible for a canal to be nourished and
 “ repaired by a Fluid which is too gross
 “ to

“ to enter into it. But all the solid parts
 “ of the body are made up of nerves
 “ compacted and pressed together, as ap-
 “ pears from observations made on the
 “ growth of the chick in the incubated
 “ egg ; and that of the human embryo ;
 “ and is yearly evinced by *Boerhaave* in
 “ his *Prælections* on the *Institutions* of
 “ *Medicine*. Therefore, whatever is an
 “ ingredient in the composition of animal
 “ solids, was before a part of the nervous
 “ fluid. Since therefore these, as *Chem-*
 “ *ists* well know, consist of earth, which
 “ is as it were the *basis* ; of oil and water,
 “ which serve as a kind of glue ; and of
 “ a certain salt peculiar to animals, mild
 “ and neutral, which by distillation in a
 “ retort, is rendered alkaline and volatile,
 “ intimately blended and united with the
 “ other principles ; it certainly follows,
 “ that the animal spirits contain all these,
 “ and that they are as it were the quint-
 “ essence of the blood and other juices ;
 “ the

“ the vehicle of which is lymph or water,
“ extremely defæcated and moveable, and
“ extremely attenuated by flowing thro’
“ vessels, which from large become gra-
“ dually smaller, and are at length les-
“ sened beyond all imagination ; rarefied
“ by heat, and approaching nearer to the
“ nature of vapour, than that of a sensible
“ fluid ; which water is impregnated with
“ the before-mentioned earth, oil and salt,
“ all extremely attenuated and intimately
“ mixed together, and imperceptible to
“ all our senses, till, after the nutrition of
“ their proper canals being perfected,
“ they are fixed into a solid and confi-
“ stent substance. From all which it is
“ evident, that it is neither necessary nor
“ free from error, to liken animal spirits
“ unto the particles of light, urinous or
“ fermented spirits, or any other liquid
“ whatever, differing from that we have
“ just now described. NOR DO I THINK
“ THAT

“ THAT ANY ONE THING, EVEN IN THE
 “ ELEMENTS OF GEOMETRY, MORE EVI-
 “ DENTLY FOLLOWS FROM DATA, THAN
 “ THIS POSITION FROM THE EXISTENCE
 “ OF ANIMAL SPIRITS, BEING LAID
 “ DOWN OR TAKEN FOR GRANTED.”

The reader will be pleased to observe, that in this passage Boerhaave is spoke of as then living and continuing his yearly lectures; but he died in the latter end of September, 1738; and therefore that this discourse was written before his death. And accordingly it is dated June the first, 1738. But by the accident of the Printer's failing, to whom the copy was delivered, it was not published till above a year after.

When I was writing the above translated passage, I had no books by me, that could be of any use with respect to the subject I was upon, but Boerhaave's Institutions, Cheyne's English Malady, and the second edition of Monro's Osteology, to which is

a

subjoined

subjoined a description of the nerves : from which last treatise, I translated and inserted in my discourse his account of the celebrated experiment on the phrenick nerve. I had read, many years before, most of the authors of note, that treated of the nerves and nervous fluid ; and was pretty sure that none of them had suggested any thing, which at any time had made the least impression on my mind, so as to lead me into that opinion, concerning the nature of animal spirits, which is there delivered. And this made me the less sollicitous to be at the trouble of procuring them, and reading them over anew on this occasion. As for the three books I have mentioned, it is evident they contain nothing that hath the least tendency that way.

After my book was printed off and published, being wholly taken up with the practice of physick and practical studies, I thought no more on this theoretical subject,
till

till a few months ago, when the celebrated Haller's *Physiology* first fell into my hands. As I was no stranger to that author's learning and abilities in every thing relating to the animal œconomy, I forthwith purchased it, and upon a careful perusal, found it in the general, to contain according to my own judgment, by far the fullest, as well as the most correct account of the functions of the human body, that hath yet appeared; a treasure rather than a book. But it was with a particular eagerness and attention, that I read over and over his paragraphs on the nerves and nervous juice, my old favourite subject. In these I found him a zealous, as well as able stickler for the cavity of the nerves, and the reality of a nervous fluid. And his summary of the arguments for the affirmative, appeared so pithily drawn up, that I thought I could not dispense with inserting a literal translation thereof in the treatise. Some such summary

was necessary in its proper place, and I could do nothing of my own so well.

But tho' he appears as fully convinced of the existence of a fluid in the nerves, as the abstruseness of the thing will permit a wise philosopher to be, yet he is perfectly a sceptick with respect to its nature and constituent parts; and after recounting all the different opinions of writers on that subject he could think on, declares himself dissatisfied with every one of them.

It is certain that he was apprised of my book, as it is not omitted in the catalogue of medicinal writers he hath lately published, in his edition of Boerhaave's Method of studying Physick, corrected and enlarged. It would likewise appear by his manner of mentioning it, that he had perused it with some attention. But the passage we are now considering, seems to have made no impression upon him in its favour. I incline

cline to believe, he might the less regard it, because I there take it for granted, that, according to Boerhaave's doctrine, all the solids in the animal body were originally nerves; an opinion which he himself disputes, and contends that at least some part of them are made out of the cellular membrane, without having ever been in a nervous state. But independently on such a supposition, the sole nutrition of nerves in the adult animal body, which are to undergo no subsequent change, is a sufficient foundation for my reasonings.

However that be, the modest diffidence of so great a man, and his backwardness to draw any definitive conclusion concerning the nature of a nervous fluid, with all his extensive and accurate knowledge of these data, which were most likely to yield a satisfactory and scientific one, sensibly affected me, who had, many years before, so hardily and peremptorily pronounced in
print

print upon the matter ; and determined me to review and re-examine what I had then offered to the publick.

And first, I set about enquiring whether any author before the year 1740, being that in which my book was printed, had broached the same opinion. I might fairly go up as high as 1738, my papers having been then delivered to the Printer ; and even to 1735, as in that year I had printed the first book of the Poem, in which the substance of the doctrine is clearly delivered, and applied to practical purposes, as may appear from some passages thereof, likewise to be found at the end of this preface ; copies of which first book printed in 1735, were read by many in Yorkshire, and particularly by the learned and celebrated gentleman already mentioned, to whom the prose discourse in the form of an epistle was addressed ; and some of them may be still produced. With this view, and for this purpose,

pose, I consulted Bohnius, Verheyn, the latest editions of Boerhaave's Institutions, and his Prælections on them as published by Haller with his own additional notes; but could find nothing at all to that purpose in any of them. As these authors mention and take under consideration, all the different opinions of former writers on this subject, that are worth notice, I judged it unnecessary to turn over any more.

But reading downwards, I had the satisfaction and pleasure to find my system adopted and followed by that unexceptionable judge of every thing, whether speculative or practical, that pertains to the medicinal art, Professor MONRO, in his most elaborate and instructive treatise on the nerves in general, added to the third and subsequent editions of his Osteology, and printed in 1741, the year after my Latin book was published; a copy of which was transmitted to him soon after its publication. In that treatise of the nerves sub-
joined

joined to his second edition, there is not the least vestige of any thing tending to unfold the constituent parts of the nervous fluid, as I have already observed; but in this, he not only adopts my doctrine, but illustrates and confirms it by a variety of arguments. He mentions not indeed my name, because he sets out with the resolution of mentioning no names at all, to avoid animosities or disputes. “ I have not, says
 “ he, named one author, flattering myself
 “ that those I was under a necessity to re-
 “ dargue, might be the better concealed, by
 “ my not declaring whom I approved of.” In the preface to his fourth edition, printed in 1746, he expresses the same thing in other words, “ I have not only concealed
 “ the names of the writers whose sentiments
 “ were different from mine, but have shun-
 “ ned quotations from those I approve of,
 “ lest the knowledge of the latter, should be
 “ a key to discover the former by.” Here, with submission to my much esteemed master, I cannot help thinking the cautiousness that

restrained him from doing justice to these authors he believed were in the right, for fear of disobliging those he was sure were in the wrong, to have been somewhat outrée or too far pushed; tho' perhaps it is more excusable in a publick professor, than any other writer. It certainly hath a natural tendency to stifle or blunt the keenest of all incentives, to labour for the advancement of arts and sciences, to wit, the desire of honest fame, and of reaping the advantages arising therefrom. If such a conduct obtained universally, the broachers of any thing new, however ingenious or useful, would seldom or never see their names in print, except in the title pages of their own books; and compilers would have a manifest advantage over original authors.

To place this my system, for so I have an undoubted right to call it, as, I hope, is evidently made out, in a clear light; to render it more conspicuous by its appearing single and uneclipsed by more showy companions,

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panions, the reverse of which hath been its fate hitherto, is my design in the following pages. I have, not out of ostentation, but for the sake of method, precision, and force or weight, thrown them into the form commonly used by geometrical writers. Moreover, I apprehended, that by this way of ranging my thoughts, the reader will be enabled more easily to spy out any material slip or fallacy in the reasoning, should there be such, than he well could in an uniform discourse, not marked out into distinct parts, by the titles of Lemma, Proposition, or Corollary. And as I perceived, that the celerity of muscular motion was a principal ground of doubt with Haller, and through his authority would questionless have the same effect upon many others, I have taken it into close consideration, and endeavoured to clear up that grand difficulty.

If it should be asked to what useful end this abstruse enquiry tends, I would readily answer, to round as it were, and in some

measure complete our idea of the animal body, which the parent of medicine, the divine Hippocrates hath compared to a circle : to explain the nature of the τὸ Εἰσπυρόν, the impetum faciens, or the immediate corporeal cause of motion, the effects of which we see and feel, while itself is hid from our senses, and discoverable only to the eye of reason and science ; and, which is the chief advantage of our theory, to shew all to be consistent with and analogous to animal nature, as considered in itself; and as it were within its own estate, without going abroad for, and obtruding foreign and unnecessary beings or properties ; but evincing by argument what Hippocrates smelled out by sagacity, to wit, that corpus ipsum sibi ipsi idem est, & ex iisdem conflatum. But the utility of our enquiry doth not stop here. As the same impetum faciens, or active fluid, hath a very large share of influence on the disorders of the animal machine, the clearer, juster, and fuller ideas we have of its nature and constituent parts,

the more masterly and comprehensive will our knowledge be of the various diseases in which it is materially concerned, and of the methods and remedies requisite for their cure.



PASSAGES referred to in the PREFACE.

Dissertation. epistolar. pag. xxx. et seq.

ANtequam hanc materiam missam faciam, breviter de natura spirituum animalium inquirendum. Etenim quotquot autores me legisse memini, nec in praesenti sunt libri ad manum, minus de ea re satisfaciunt. Quin potius miror obviam quandam, et facilem ratiocinationem iis in mentem non venisse, quae est hujusmodi: Quum spiritus animales sint liquida omnium in corpore animato subtilissima, debent nervi ab iis solis alii et nutriri; impossibile enim est canalem aliquem nutriri a liquore crassiore, quam ut eum ingredi possit. At vero omnes in corpore partes solidae ex nervis compactis et coagmentatis fabricantur, ut ex observationibus capit de pulli in ovo incubato, et humani embryonis incremento patet; et quotannis in praelectionibus suis theoreticis confirmat Boerhavius. Ergo quicquid

quid solidarum partium compositionem ingreditur fuit ante in nervorum liquidis. Quum autem eae, ut norunt Chymici, consistant terra, quae veluti basis est; oleo, et aqua, quae glutinis loco inservit; et sale quodam animalibus proprio, blando, neutro, quodque distillatione per retortam alcalinum, et volatile redditur, cum reliquis principiis intime misto et unito; utique sequitur spiritus animales omnia haec principia continere: ac proinde esse velut quintam, ut loquuntur, essentiam sanguinis et succorum reliquorum: cujus vehiculum est aqua, vel lympa purissima, mobilissima, fluxu per vasa, quae gradatim ex capacioribus augustissima, et ultra omnem imaginationem subtilia deveniunt, admodum attenuata; calore rarefacta; et vaporis potius, quam fluidi sensibilis naturam referente; quae simul imbuitur terra, oleo, et sale praedictis; itidem tenuissimis, maximeque elaboratis, et subactis, intimeque permistis; quaeque omnes sensus fugiunt, antequam propriorum canalium nutritione peracta, in substantiam solidam et consistentem tandem conversa sint. Unde quidem patet nec esse necessarium, nec erroris expers, spiritus hosce comparare cum particulis luminis, cum spiritibus urinosi, fermentativi, vel cum alio quovis liquore ab eo discrepante, quem modo descripsimus. Nec puto quidquam, vel in elementis geometricis evidentius ex datis sequi, quam placitum hocce ex posita spirituum animalium existentia.

Neuropath. lib. I. vers. 241. et seq.

Praeterea longo si duret tempore labes,
 Debilitabitur ulterius, languensque fatiscet
 Daedala nervorum, et teneri structura cerebri:
 Nimirum quoniam a crudo, vapidoque liquore
 Nutritum debent omnem trahere, atque ali-
 menta.

Omni etenim momento animali in corpore vivo
 Extenduntur, et elongantur tenuia vasa,
 Vi propulsorum jugi distracta liquorum:
 Diductis hinc a se partibus attenuantur:
 Finesque avulsi franguntur, et abraduntur;
 In cute squamarum forma specieque cadentes,
 Aeris attactu desiccati, atque coacti:
 Interne vero liquidis mixti abripiuntur.
 Ast interstitia, et defectus inde relictos
 Non alius supplere liquor, sarcireve possit,
 Quam qui eadem penetrans pertransit et alluit
 usque.

Nervi igitur tenues nimirum, et molle cerebrum
 Nutritum a propriis liquidis quaerunt, capi-
 untque;

His etenim mage nequaquam subtilia dantur,
 Ast eadem vero male cocta, et inertia si sint,
 Debiliter compingantur, laxaeque necesse est,
 Quois nervi constant structi, cerebrumque ele-
 menta:

Proptereaque ipsis robur virtusque fatiscat.

Ibid.

Ibid. vers. 276. et seq.

Scilicet ille liquor, qui sanis continet in se
Attenuata, probeque simul permista elementa,
Nempe salem, blandumque oleum, terraeque
minuta

Corpora, subtili lymphae fluitantia rore ;
Vi vitae valide conquassata atque subacta ;
Degener hoc morbo factus, vapidusque aque-
usque ;

Paucaeque complectens elementa animalia pau-
per ;

Mobilitate celer nimia, nimiumque solutus
Diffluit, et nervis subito nimis evolat ipsis.
Et cerebri, nervumque, valentibus et bene sanis
Quae contenta gradu quodam, atque elastica
constant

Stamina, pro sexu variaque aetate animalis ;
Compactisque vigent inter se firma elementis ;
Debilitata mala labe, et compagine fracta,
Intempestiva mollescunt flacciditate :
Dum crudus, tenuisque humor nimis alluit omnes
Anfractus, tortusque vagos, cellasque cerebri.
Nervorumque tubos, et flumine macerat udo.
Quin et debiliter conjectis ipse elementis,
Ut docui supra, teneras male nutrit, alitque
Nervorum et cerebri fibras, et daedala vasa ;
Virtutem roburque evertens corpore toto.



The two following Books,
Sold by A. MILLAR in the *Strand*.

NEUROPATHIA;
SIVE DE
Morbis Hypochondriacis et Hyſtericis,
LIBRI TRES,
POEMA MEDICUM.
Cui praemittitur
Differtatio Epistolæ profaica ejusdem Argumenti.

A
Propoſal for the Improvement
OF THE
Practice of MEDICINE;
Illustrated by an Example relating to the
SMALL-POX.

To which is added,
A DISCOURSE ON *Medicinal Indications,*
Specificks, and Panaceas,
Wherein are introduced ſome Remarks on a
Book, entitled *Siris*; and the Properties of
Tar-Water.

Both by *Malcolm Flemyng, M.D.*

T H E

Nature of the nervous fluid or
animal spirits demonstrated.

A S S U M P T I O N .

Nerves are hollow canals or tubes,
the smallest of all in the animal
body, which contain and transmit
a peculiar juice or fluid.

MY intention in this paper, is not
to demonstrate the existence of
a nervous fluid, but to investi-
gate and find out the nature of such a fluid,
supposing it actually to exist. I pretend to
add nothing material to the cloud of argu-
ments, which great men have already used

in order to establish that position, and which I, for my own part, believe to be unanswerable. But that the reader may judge for himself, I shall lay before him the words of the very learned *Haller*, in which their substance is briefly as well as pithily set forth. The position itself being too far removed from self-evidence to be termed *Axiom*, nor with propriety to be stiled *Postulatum*, as it requires nothing to be done or executed ; and being supported with too many weighty arguments to be dishonoured with the name of *Hypothesis* or supposition, nor to be called Proposition in the geometrical sense of the word, because a formal demonstration is not subjoined ; I have, upon these accounts, chose the appellation of Assumption. The reader may, if he pleases, term it *Datum*, or a thing given, or taken for granted. But I proceed to quote *Haller*.

Parag. CCCLXXXVI. “ The controversy
 “ begins concerning the nature of that
 “ fibre, which with others like itself, con-
 “ stitutes both the *Medulla* and nerves.
 “ Many of the moderns have assumed
 “ that it is solid, so as only to be moist-
 “ ened by a vapour exhaling into the
 “ cellular texture enveloping the nervous
 “ fibres.

Parag. CCCLXXXVII. “ The strong rea-
 “ sons which we shall adduce, do not
 “ permit us to embrace this opinion.
 “ The cortical part of the brain is vas-
 “ cular every where, and is continued to,
 “ and coheres with the medullary part
 “ by an uninterrupted inextricable con-
 “ nexion, in so manifest a manner, that
 “ there is no room for the least cavil to
 “ make the thing doubtful. Then, a very
 “ great quantity of blood comes to the *Cor-*
 “ *tex* of the brain; see Numb. CCCXXXIX.

“ and lastly, the *Medulla* and *Cortex* con-
 “ stantly grow in all dimensions in the
 “ same proportion. From all which duly
 “ weighed, I conclude that the small ves-
 “ sels of the *Cortex*, of which it is solely
 “ composed, N. ccclix. are continued to
 “ the fibres of the *Medulla*, of which that
 “ is likewise wholly made up; and there-
 “ fore, that they are not solid, since, if
 “ that were admitted, a very copious fluid
 “ arriving at the *Cortex* through the *ca-*
 “ *rotid* and *vertebral* arteries, must return
 “ useless, because beaten back by the solid
 “ *Medulla*. And besides, the proportional
 “ increase of the *Cortex* with that of the
 “ *Medulla*, manifestly points out one com-
 “ mon cause of both their growths. And
 “ that is by N. ccxlix. the superior force
 “ of the heart, which extends and length-
 “ ens the blood-vessels. It remains then
 “ to conclude, that the *Medulla* is likewise
 “ made up of vessels, which may be di-
 “ stended by the same force of the heart.

CCCLXXXVIII. “ The phænomena of
 “ wounded nerves do not suffer us to
 “ believe them to be solid. For, if a
 “ nerve shakes when irritated, in the man-
 “ ner of an elastic chord, which trembles
 “ when struck, it should be composed of
 “ hard fibres, whose extremities should be
 “ fastened to firm bodies, and bent; for
 “ strings that are either soft, or unbent,
 “ or not made fast, cannot sound. But
 “ all nerves are medullary in their origin,
 “ and very soft, and very far from being
 “ tended. For some of them all over their
 “ lengths are soft in every part; for in-
 “ stance, the olfactory nerve, and the soft
 “ portion of the auditory nerve, from
 “ which latter we might most expect vi-
 “ bration, as it is the instrument of hear-
 “ ing, which is excited by sound. Then
 “ tho’ nerves are somewhere hard, yet
 “ they grow soft in the *Viscera*, in the
 “ muscles, and the sensories, before they
 “ exert

“ exert their functions. Therefore ner-
 “ vous fibres, as they are neither stretch-
 “ ed in their beginning, nor termination,
 “ cannot vibrate through elasticity. But
 “ moreover, in peculiar and very remark-
 “ able instances, it is impossible they should
 “ tremble, because they are, for a great
 “ part of their passage, tied down firmly
 “ to hard parts by the cellular texture;
 “ for example, the nerves of the heart are
 “ fastened to the great arteries and *Peri-*
 “ *cardium*. And last of all, the following
 “ experiment demonstrates the nerves to
 “ be entirely void of elasticity; to wit, a
 “ nerve cut asunder neither becomes short-
 “ er, nor draws back its divided extre-
 “ mities towards the firm parts, to which
 “ it is fastened, but becomes somewhat
 “ longer through laxity, and thrusts out
 “ its *Medulla* into a round tubercle.

CCCLXXXIX. “ Add to all this, that the
 “ influence of an irritated nerve is never
 “ pro-

“ propagated upwards, muscles above the
 “ place of irritation never being convulsed,
 “ however much firmer the trunk of the
 “ nerve there be. This is entirely foreign
 “ to the nature of elasticity, for a chord
 “ struck, propagates its tremors equally to
 “ both ends from the place of percussión.
 “ This shews that there is a fluid, which
 “ comes from the brain, and flows down
 “ through the nerves to the extreme parts,
 “ the motion of which fluid being acce-
 “ lerated by irritation, acts solely in the
 “ direction of its current, and cannot pro-
 “ duce convulsions upwards, as new fluids,
 “ issued from the brain, prevent that effect.
 “ Nor is that experiment in the *phrenick*
 “ nerve to be disregarded here, by which
 “ it appears, that it being compressed, but
 “ at the same time rubbed downwards,
 “ assists the motion of the diaphragm, and
 “ when rubbed upwards, stops its motion
 “ altogether : From which it is almost
 “ evident, that by the former direction of
 “ force,

“ force, the progress of the nervous fluid
 “ is urged on, and by the latter it is coun-
 “ teracted; and that the nerve acts not
 “ after the manner of a chord, which
 “ could never tremble upon being com-
 “ pressed, in whatever direction the com-
 “ pressing finger acted.

cccxc. “ I therefore think it almost
 “ absolutely certain, that the nervous fibres
 “ are hollow, and that they exercise their
 “ functions not by their spring, but by
 “ the motion of their proper fluids. Nor
 “ is the extreme smallness of these canals,
 “ which no microscope can reach, an ob-
 “ jection of any weight against the expe-
 “ riments above-mentioned; nor the ab-
 “ sence of tumor in a nerve upon being
 “ tied, which is not altogether true; nor
 “ other arguments of the like nature,
 “ which only prove the imperfection of
 “ our senses, but avail nothing against the
 “ actual

“ actual presence of nervous spirits.” Thus much from *Haller* *.

To this excellent summary let me subjoin some brief Reflexions. Here is a proof drawn from the most accurate and minute examination of the parts concerned, and helped out by an experiment, which is directly in point, to evince the existence of a nervous fluid, that seems to be as valid and convincing, as the nature of the thing can well admit of, where the Testimony of our senses cannot reasonably be expected. And it is, I think, much more to be wondered at, that, in so abstruse an enquiry, human penetration should have been able to proceed so far, than that it hath made no farther advances. At the same time, there are arguments produced which absolutely and beyond all manner of doubt, demonstrate that the action of
the

* *Primæ linæ Physiologiæ*, 1747.

the nerves cannot possibly consist in tremulous vibration caused by elasticity. To acquiesce in an opinion so ill founded and so easily overthrown, argues either a gross ignorance of the animal structure, or, which is more culpable, a supine or wilful inattention to it. Besides that, if such vibrations were admitted, however commodiously they might explain sensation, they could nowise account for muscular motion; for what hath trembling to do with traction or pulling? so that they, who maintain the opposite side of the question, before they can make a tolerable figure in their own defence, have a double hard task to get over; to wit, first, to shew the un-conclusiveness of these arguments, which tend directly, and as it were *a priori*, to prove the nerves to be hollow canals; and when that is done, if it could be done, to point out a feasible way, in which sensation and muscular motion can be carried on, without either a nervous fluid, or
elastic

elastic tremor: The first being what they themselves deny, and the latter proved altogether untenible. To hit upon such a medium, I humbly apprehend they will find it far from being easy.

If the reader desires to see these Matters treated of more at large, let him consult *Haller's* edition of *Boerhaave's* Prælections, with his own Notes; and Mr. *Monro's* elaborate and instructive discourse on the nerves in general.

As the nerves are admitted to be hollow canals, it must be granted, that they are the smallest of all in the animal body, for this very reason that their cavities are disputed.

L E M M A I.

The animal solids consist of phlegm or water, of oil, of a peculiar mild neutral essential salt, which

by putrefaction and distillation, becomes alcalious and volatile, and of earth, in the chymical sense of the word ; to which last is owing their firmness and stability. Of these principles, intimately blended together and incorporated, all the solid parts of the animal body are made up and compounded.

This is so universally acknowledged by all, that are in any tolerable degree acquainted with the animal œconomy and the rudiments of chymistry, that I might spare myself the trouble of a formal proof. I shall therefore be the less prolix upon this head.

That phlegm or water makes a part of the animal solids, is plain to ocular demon-

demonstration, as even horns and hoofs, where one would least expect to find it, by distillation in a retort yield it in considerable quantity. It must therefore be found in a much greater proportion in moister parts.

That oil is another never wanting ingredient, is evident from the same operation, by which a fetid empyreumatic oil is obtained from every solid part of the animal fabrick, without exception, unless they are previously calcined, or robbed of whatever can be extracted from them by boiling water.

That there is likewise a certain salt in the composition of animal solids, or at least the constituent parts of salt, is evinc'd by the same chymical *Analysis*, they yielding a volatile alkaline salt by distillation. That this salt before putrefaction and distillation is neutral, that is, neither acid
nor

nor alcalious, appears from this, to wit, that no humor of the animal body in a natural state, no decoction or gelly, extracted by boiling water from solid parts, discover any signs either of the one or the other quality. Even urine, when retained many days in the bladder through disease, is not then become quite alcalious.

That earth is a principal ingredient in the composition of animal solids, (which is likewise true of vegetables) appears from there remaining after incineration or calcination an insipid inodorus powder, neither dissolvable in water, nor fusible by fire, which is by chymists so termed. This earth is the firm *basis* of the other parts, and constitutes the composition a solid; without it the animal fabrick could not be organical. The other parts are but the *Gluten* or bond of union, by which the whole coheres, and acquires a certain degree of hardness and rigidity, according

according to the greater or lesser proportion of the earth to the *Gluten*. This is illustrated by the following plain instances: A hair in its natural state is tough; burn it, it retains its fibrous form, but the cohesion of its parts is lost, and you may blow them asunder; the fire hath dissipated the water, and consumed the oil that glued them together. Bones in their own nature are hard and rigid, calcine them thoroughly, tho' they retain their shape and figure, they will become friable, and may be crumbled to powder between the fingers. Dip the same bone in oil, or even in water, and its tenacity will be recovered in a remarkable degree. The process of making earthen and porcellane ware, furnishes another confirmation of the same doctrine.

C O R O L L A R Y.

The above proposition being so well evinced by the most diligent and accurate enquiries

enquirers into nature, that I believe none; but such as are disposed to cavil, will call it in question; it may be fairly reasoned from as a principle. But before I proceed to another, that I may take away, as much as is possible, all occasions of either mistake or altercation, let me observe that as the nerves are solid parts, that is, not fluid, they must be acknowledged to contain the same principles with the other solid parts of the animal structure, tho' they cannot be examined and analysed a-part; that is, separated from every other thing, which doth not properly constitute a nerve, taken in its strictest sense; as the membranes that envelope them, the cellular texture in their interstices, minute vessels, &c. To deny this, because it cannot be plainly shewn and made manifest to the senses, would be mere chicanery. If they are fibres, whether hollow or impervious, they must, according to the laws of fair analogy, have terreous elements for the basis and stay of

the other principles that constitute them, to preserve their figure, continuity and direction, and render their functions permanent, whatever these be.

L E M M A II.

The matter of the nutrition of the smallest vessels in the animal body, is supplied, at least, in a considerable measure, if not principally, by the fluids or juices, which pervade their cavities.

Fluids, however mild, constantly flowing with whatever velocity through soft canals, must create a perpetual abrasion in their insides, which would of course wear out and destroy them, unless there was a constant supply of matter to compensate that loss: This is what is called nutrition.

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In the smallest Vessels of all, as their walls or coats cannot be composed of other vessels, for then they would not be the smallest; but every distinct vessel must be one solid tube, the waste by abrasion can be made up only by one or both of the following ways; either the liquor flowing through them leaves behind it as it goes on, matter sufficient to replace what hath been abraded; or their places must be filled up by particles from without, penetrating through the whole thickness of the canals, and settling in the same holes or vacuities, from which the *Ramenta* were torn and carried off with the permeating fluid. By one or other, or both of these ways, and by these only, can the vessel be preserved sound, and of the same figure and dimensions, for any considerable time.

Let us apply this doctrine more particularly to the nerves, which, according to the Assumption, are the smallest vessels in the animal

animal body. As they are distinct filaments, sheathed over with thick-woven tenacious membranes, and tied closely together in bundles, parallel to one another, except where they are divested of these membranes, and spread like *Mucus*, as the *Retina* is for example; the only way they can receive their nourishment from without, is by a vaporous moisture, penetrating both through their membranes, and the whole thickness of their coats, and leaving nutritive particles fixt in the gaps and breaches, from which the abraded ones were torn and swept off. And this supply must constantly keep pace with the abrasion itself, if the nerves are nourished no other way.

That this is neither the only, nor the principal way of the nutrition of nerves, will, I hope, appear from the following considerations.

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First,

First, It is repugnant for it to be so, to the general manner of nutrition in the other vessels of the animal body, as acknowledged by modern authors, who have gone farthest into the consideration of these matters. They allow a nutritive or plastic quality in the fluids, which immediately repairs the breaches made by abrasion as they go on, tho' they have not taken the nutrition of nerves into consideration.

Secondly, It is not agreeable to the simple and direct procedure of nature, to have the whole or greatest part of the matter of nutrition brought from without, when the whole or greatest part of the waste or *Dispendium* is made within.

Thirdly, The supply from without by a vaporous moisture, or any other contrivance whatever, that can well take place in the animal body, is too uniform to keep equal pace with the abrasion made by the nervous
fluid,

fluid, which upon different occasions is very different in the same nerves ; and always different in different nerves, according to the nature of the functions they influence. Let us for instance suppose, a seamstress working twelve or fourteen hours in the twenty-four. There is in that case, a quick long continued motion of the nervous fluid in these muscles, which move the fingers and arm ; and yet the supply of a moist vapour can be little or nothing more, than if these muscles were at rest, as the heat of the body is little or nothing raised by that kind of work. The heart in a person in health beats 5000 times in one hour ; but its nerves can be no more liberally furnished with a nutritive vapour from without, than other nerves in the circumjacent parts, which preside over much slower functions.

Fourthly, It is inconsistent with the extreme subtlety and tenuity, if I may use
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the word, of the nervous fluid, to maintain that the canals, through which it flows, are repaired solely or principally by the apposition of particles from without, penetrating through the whole thickness of their coats or walls. As the nervous fluid has impulse and motion on its side, while the nutrient moisture is comparatively at rest, supposing the ultimate particles of both to be equally attenuated, the nervous fluid will more readily penetrate through the sides of its own canals, than the nourishing moisture, either in the way of nutrition or evaporation. It is hardly to be supposed, that they are less divided and comminuted, than the nutritive particles in the vapour; now that they are arrived at the cavities of the smallest vessels, and therefore have undergone the whole process of the operations of the animal fabrick and œconomy.

Lastly,

Laſtly, The uniform and proportional growth of the whole brain, the medullary, and the nervous ſyſtem, as it affords an invincible argument to prove their texture to be vaſcular, ſo it carries ſcarce leſs weight with it to incline us to believe that the chief matter of their accretion, and conſequently that of their nutrition, is conveyed through the channels of their minuteſt canals, and therefore is applied principally to their infides; ſo complex and intricate an organiſed texture, can hardly be conceived to be increaſed gradually and uniformly, in ſuch an infinite number of diſtinct mæanders and receſſes, by means of a nutritive moiſture ſoaking indifcriminately through the whole maſs.

From all which I conclude, that the chief matter of the nutrition of the nervous tubes, is furniſhed by the fluids which they tranſmit, and applied within their cavities ;

cavities; and that the vaporous moisture, we have had so oft occasion to mention, is principally employed to keep the membranes in repair, as their structure is less organised, and they lie most opportunely to receive its benefit.

PROPOSITION.

The nervous fluid or animal spirits, consists of phlegm or water, oil, animal salt, and earth, all highly attenuated and subtilised, and intimately mixed and incorporated together.

All animal solids contain these principles, and the nerves amongst the rest by *Lemma* first, and the Corollary drawn from it: The nerves are nourished principally by the nervous fluid according to *Lemma* second: But that fluid cannot give to the
nerves

nerves what it contains not itself; therefore the nervous fluid must contain some proportion of all these principles. The nerves are the smallest of all the vessels in the animal body, according to the *Assumption*; therefore the fluid they transmit must be made up of parts highly attenuated and subtilized, and intimately mixed and incorporated together, in order to be fit for being moved through so minute canals, freely and without obstacle. Which is what was intended to be proved.

S C H O L I U M.

It will no doubt appear strange, that an enquiry seemingly so abstruse, should terminate in so great simplicity. But that is the case with many truths of the greatest importance. It will likewise be natural here to ask, how it is possible that muscular motion can be caused by such a fluid, with all the circumstances of force

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and celerity, especially the latter, that it is attended with? and other questions of the like kind. To which I have a right to answer, that, from the nature of the subject I have undertaken to treat of, I am not obliged to say any more than what is already said upon these matters, unless my reasonings are found fault with; in which case, I should think myself under an obligation, as well in point of deference to the publick, as justice to myself, to defend them if I could, or give up the cause. If I am in the right, there is some addition made to the general stock of natural knowledge; and I may leave it to others to proceed farther, as their abilities and opportunities may permit. This, I say, I have a right to answer. But I shall take this opportunity to add some reflexions, which at present occur to me, that have a pretty close connection with our subject.

In the first place, I pretend not to prove that there is nothing else in the nervous fluid, besides the principles I have enumerated. But these principles, I affirm, it must consist of, if the nerves are canals, and contain a fluid. There may be in animal fluids in general, and that of the nerves in particular, some subtle æther, fire or spirit, or whatever other name it may be called by, diffused through the atmosphere, and perhaps over our whole system, acting by laws unknown to us, and in a particular manner in organised bodies ; I say, there may be such a spirit necessary to cause muscular motion in co-operation with the proper fluid of the nerves, which is the product of the animal fabrick and œconomy, and yet all my reasonings stand good. Be that as it will, certain it is that the nervous fluid I have described, if there is really a nervous fluid, is at least a *conditio sine qua non* of

sensation and muscular motion. A nerve compressed between the fingers, or tied round with a thread, immediately ceases to act; as soon as the compression or ligature is taken off, sense or motion returns; which evidently shews, that no æther or universal spirit is sufficient to excite the functions depending upon a nerve, though the nerve is entire, without the presence and co-operation of its proper liquid. To show that a fluid in the nerves is the immediate cause of muscular motion and sensation, and to explain and unfold the nature of that fluid, considered as an animal production or juice, is enough for the physician, without ascending higher into general and remote causes.

The ready, and as it were instantaneous production of muscular motion upon the determination of our wills, and the amazing celerity thereof in a thousand obvious instances, as in a musician, for example,

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playing upon an organ or violin, or a drummer rolling, hath induced ingenious and speculative men to look about, and search for such causes as might be adequate to that wonderful effect. I shall therefore take this point into consideration here, repeating some things, which I have touched upon in a *Latin* discourse, published eleven years ago *.

Time is infinitely divisible, as well as matter or extension. A musket-bullet describes a certain line in a second, suppose an hundred yards, which is but a very moderate length to assign it: An hundred yards contain 3600 inches. It therefore describes an inch, taking its velocity from first to last at a medium, in the 3600th part of a second; the tenth part of an inch, in the tenth of that time, and so on. Now every preceding part, however minute, of this line of an hundred yards, must be got
over

* Neuropathia, printed 1740.

over before the bullet can arrive at the next. Hence we see that the divisibility of time keeps pace with that of a line, which mathematicians have demonstrated to be infinite, and which this single example is sufficient to convince us of.

Time is measured by motion, and motion in its turn is measured by time. That portion of time in which a body describes a line of two inches, is double that in which it describes but one with the same velocity ; and that velocity with which a body describes a line of two inches, is double that with which it runs over but one, the times being equal.

Length and shortness of time, and slowness and celerity of motion, are only relative or comparative terms ; there being no absolute universal standard above or below which, any definite portion of time can be
called

called long or short, or any definite progress of motion, slow or quick.

In like manner, no part of matter or extension is absolutely great or small, but relatively, as different portions thereof are compared together.

Our senses are limited within a narrow compass, being solely, but perfectly adapted to that state, in which infinite wisdom hath placed us, and to the parts we are intended to act there. Our imagination keeps pace with our senses, as it is only the copy or picture of our sensations. Thus we cannot truly form in our minds, the image of either a larger or a less space, than our sight can take in or perceive. We can indeed think of such a space, and talk and reason about it; but that is intellect, not imagination. And we can frame no image of a part of time, smaller than our perception of the progression of motion

tion will permit. The more distinctly we can perceive the progress of the body moved thro' the successive small parts of the line it describes, the slower its motion appears; the nearer we are losing that perception, the motion appears so much the swifter; and when we actually lose it, the translation of the body seems not progressive but instantaneous. This will be very much illustrated by the following familiar example.

There is nothing more certain, than that the production and diffusion of sound is not instantaneous, but requires a determined time to be propagated in, answerable to the distance to which it is extended. By undoubted experiment, it is found to move something more than one thousand feet in one second. But even in a large room we are not sensible of this progression, and can perceive no interval of time between the motion of a speaker's lips, and
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our hearing his words. The reason is plain, sound moves above fifty feet in the twentieth part of a second, which is a division of time much too minute for our senses to distinguish, or imagination to represent.

A similar manner of reasoning will, I think, be of no small use to clear up the grand difficulty in muscular motion, to wit; that concerning its quickness and celerity. If the interval between the exertion of our will, and the execution thereof, by the influx of nervous juice or animal spirits, into the muscle or muscles of voluntary motion, intended to be employed, be so small a part of time, as not to be measurable by our senses and imagination, then shall the effect of our will appear to be instantaneous. But methinks this is not so extremely wonderful, that it should prove a stumbling-block to so many great men in this enquiry; especially if we add

to what hath been already said, the following considerations, first, that since the nerves are always full of their proper fluid, it is not necessary that that portion thereof, which actuates the muscles employed, should travel all the way from the *sensorium commune* or origin of the nerves, to the muscles themselves; because the parts *à tergo*, impel and push on these that go before; secondly, as in a state of rest the antagonist muscles are equally ballanced with one another, a very small additional quantity of fluid will be able to conquer the *Æquilibrium*.

From all which it appears plain to me, that, tho' our nerves were much longer than they are, the contraction of muscles employed in voluntary motion, may, and even must succeed upon the exertion of our will, in a much shorter interval of time, than can be the object of our perception, and therefore seem to us instantaneous.

taneous. And from this single position the greatest celerity of motion or action ever observed in the human body, may be easily deduced ; so great is the simplicity of truth !

We shall for clearness sake, give one example of the manner of making the deduction, which, with a proper allowance for diversity of circumstances, may serve for explaining any other species of voluntary motion how swift soever. There are few such motions in the human body carried on with greater agility, than that manner of beating the drum, term'd rolling ; this is performed by the alternate action of the flexors and extensors of the *Cubitus* or fore-arm, and the wrist : The most dextrous drummer cannot strike the drum with one stick, above five times in one second, and, I believe, even that is more than can be executed : At every stroke the stick is both lifted up and im-

pelled downwards ; and therefore, let us reckon ten vibrations in the space of one second. Let us suppose the hand that holds the stick, to move four inches every vibration, which is by much too great an allowance, considering, that the quicker this alternate motion is, the hand describes the shorter arches. Now, in the same time that the hand describes an arch of four inches, the sound produced by one stroke on the drum, moves above 100 feet, or 1200 inches ; so that the motion of the hand is more than 300 times slower than that of sound. But the muscles which influence this motion of the hand, move much slower themselves, as they are inserted near the center of motion. And upon this account, a considerable abatement in estimating the velocity of the nervous fluid is to be made.

The rapidity of the succession of action in one muscle or set of muscles, after that
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of another, needs not create much difficulty, if we attend to what hath been said. As the will can quickly and in appearance instantaneously actuate some muscles at first, so it can the next physical moment actuate their antagonists, at the same time dropping or ceasing to influence the former motion ; which, it may again as quickly produce, and so on. The one being stopped, the other is equally at freedom to take place, as if none had immediately preceded ; and therefore, there is nothing to hinder a rapid alternation, any more than a single quick motion.

Why the quickest muscular voluntary motion in the human body, which is at least an hundred times slower than the motion of sound, may not be produced by the influx of a fluid, such as I have described, into the organism of a muscle, I do not see. This difficulty seems to be one of that kind of bugbears, which proves
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such only, because it is not closely look'd into. If it were practicable to magnify time to the sense, as microscopes magnify extension, we would as readily admit, that the greatest celerity observed in animal motion, might be brought about by a fluid consisting of animal principles, as we acquiesce in the belief of the extreme exility of animal tubes, which glasses demonstrate. The latter surpasses our natural imagination and perception, at least, as far as the former.

But after all, what can the most subtle fluid in the animal body consist of, but the same principles which constitute the blood, out of which it is made, sufficiently attenuated and subtilised by the organical operations of the live machine? Is not the chick formed entirely out of the white of the incubated egg? Its flesh, bones, beak, &c. and its spirits into the bargain? And does not the white of the egg consist of
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the principles we have so often mentioned, to wit, water, oil, salt and earth? And are not these principles unchangeable in their natures by any degree of heat, or any solvent within the body? Water must be admitted as the vehicle. And is it to be supposed, that any strainers can purify the animal lymph perfectly, and free it from all mixture of salt and oil? And what is to hinder highly subtilised earth to be incorporated and pass with the rest? Why is the attenuation and mobility of such a fluid to be limited, any more than the exility of the canals in which it flows?

As to that ultimate difficulty, concerning the manner of the operation of our will upon the fluids and solids of our body, it is common to, and equal in all possible explications of animal sensation and motion. And as it may, I think, be rightly referred to the positive laws of union, between our

corporeal and incorporeal parts, that is, between mind and body, established by our all wise and all powerful creator, it only affects these minute philosophers called materialists.

F I N I S.